Oxidation Behavior of Silicon Nitride Ceramics and Mixed Alkali Effect

Henry Du, Stevens Institute of Technology, DMR-0102340

Si_3N_4 is an excellent candidate as hot-section components in high-efficiency and high-performance turbine engines. Oxidation resistance is a critical criterion in the design and use of Si_3N_4. This project aims to study the oxidation kinetics and mechanism of SN282, a turbine-grade Si_3N_4 ceramic containing Lu_2O_3 additive, and the effect of alkali contaminants. The project also aims to investigate mixed alkali effect (MAE), if any, in oxidation of SN282. MAE is referred to as orders of magnitude retardation of transport-related processes (such as diffusion and ionic conduction) due to co-existence of two dissimilar alkali cations (Figure 1, from A.K. Varshneya, *J. Am. Ceram. Soc.*, 57 37-39 (1974)). This study as revealed that SN 282 exhibits excellent oxidation resistance in dry O_2 (Figure 2). The oxidation follows a parabolic rate law with inward diffusion of O_2 as the rate-controlling mechanism. The presence of alkali elements (i.e., Na, K, and Cs) dramatically accelerates the process of oxidation of SN282 in order of Na, K, and Cs (Figure 3). The alkali-accelerated oxidation follows a linear rate law, indicating the non-protective nature of the resultant oxide layers. This study has also shown that MAE is absent in oxidation of Si_3N_4. This is consistent with the fact that oxidation of Si_3N_4 in an alkali-containing environment is rate-controlled by an interfacial chemical reaction- not by a transport-related process.

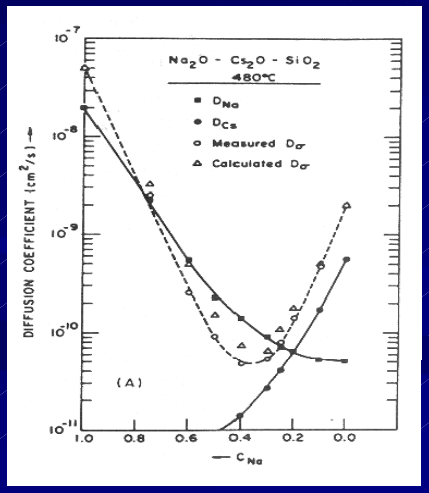

Figure 1

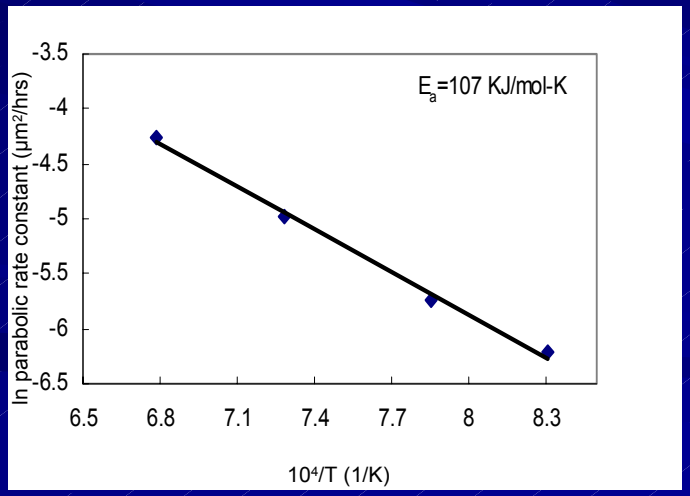

Figure 2

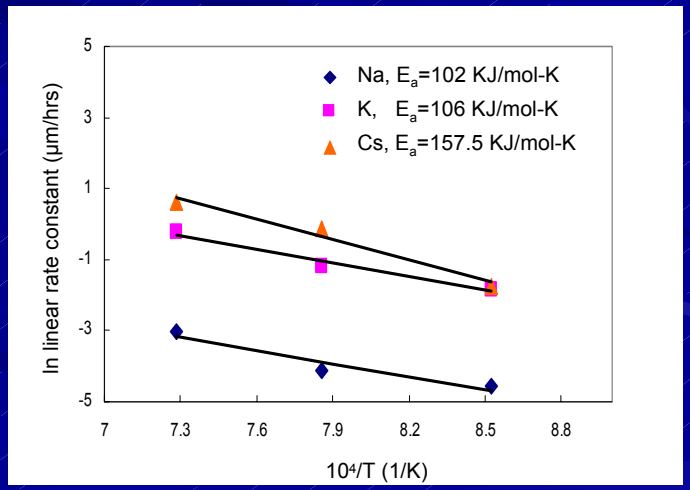

Figure 3

Oxidation Behavior of Silicon Nitride Ceramics and Mixed Alkali Effect
Henry Du, Stevens Institute of Technology, DMR-0102340

Student Training and Outreach

Madeleine Jordache (top photo) has been pursuing her doctoral thesis research under this NSF grant support. She is an American citizen and one of only three female doctoral students, out of a total of twenty-five Ph.D. candidates, in the department. Jordache has gained valuable knowledge and research experience in the project area. Her work has resulted in four oral presentations at the annual meetings of the American Ceramic Society. One paper is under review and one is being prepared for submission.

Undergraduate and high-school students have also participated in the project. As an example, Jay Cho (left of bottom photo), formerly a high-school student and now a freshman at RPI, was involved in the project in the past three summers. Cho was an award recipient at a local science fair for the work he performed.